[0050] It should be appreciated that the exemplary embodiments of this invention can be used with, as several non-limiting examples, gesture-based gaming devices, wireless communications devices, computers and appliances containing computers, robotics communication systems, communication systems for handicapped persons and navigation tables. Note that the ability provided by the exemplary ultrasonic-based embodiments of this invention to significantly reduce the physical size of the user input device(s) enables a corresponding increase in the surface are of the user display device, which is beneficial in small, handheld and portable devices, such as PDAs and cellular telephones as two non-limiting examples.

[0051] Note further that the use of the foregoing exemplary embodiments of this invention does not require the user to wear any additional hardware on the hands or fingers. Further, the scalability is improved since the size of a "finger/hand" can be reduced arbitrarily and is not limited to any certain finger/stylus size.

[0052] Described now are further exemplary embodiments of this invention, that also use user-manipulated object (e.g., finger-based) gestures, wherein the gestures are detected through the use of an imaging-type device or system, such as one incorporated into the display device, such as one constructed in accordance with the Active Matrix LCD with Integrated Optical Touch Screen (AMLCD) display device technology referenced above. These exemplary embodiments also provide for command/data definition and communication with a computation platform by exploiting finger gestures attributed to predefined commands and protocols, and are suitable for use with DDC devices that employ a minimal number of keymat/keyboards and maximized size of visual display in current and future devices. In these various embodiments, the following exemplary and non-limiting gestures and attributed commands may be employed.

[0053] FIG. **10**B shown a block diagram of an exemplary device **50** having a display **52** that is capable of recording an image of the user's finger tip(s), such as the images depicted in FIGS. **8** and/or **10**A. The display **52** in this case may be one constructed in accordance with the Active Matrix LCD with Integrated Optical Touch Screen (AMLCD) display device technology referenced above. Note that advanced scanning (e.g., text and bar codes) is possible to accomplish. In other embodiments a separate camera or cameras may be provided so as to image the user's finger(s)/hand(s), such as through the transparent surface of the display **52**.

[0054] In the example shown in FIG. **10**A the display **52** simultaneously captures images of the user's fingertips at five discrete locations on the surface of the display **52**. Note that this particular pattern may be interpreted as being one particular gesture, whereas the presence of four fingertips (e.g., not the thumb) may be interpreted as being another particular gesture. The spacing between five or fewer fingertips may be varied to encode a plurality of different gestures, as can differences in angular orientations of the fingertips one to another.

[0055] The program **18**A may be adapted to execute a program in accordance with the logic flow diagram shown in FIG. **9** (see also FIG. **6** of the above-referenced publication: 59.3, A. Abileah et al., "Integrated Optical Touch Panel in a 14.1" AMLCD").

[0056] In general, the tips of fingers are extracted from the captured image and the extraction results are recorded. Based on these records, the system decides whether to begin the recognition process. Regardless of whether the recognition process begins, the system also needs to determine whether to and when to delete stored records (this may be timer based). Whenever a new image is captured, all or at least some of the steps are repeated.

[0057] The fingertip in the captured image (feature **40** in FIG. **8**) can be considered as an object described by data expressive of, as non-limiting examples, a center of gravity, a bounding edge, and a different brightness than the background. There are many image segmentation methods that may be used for fingertip image extraction. One exemplary and non-limiting segmentation method is the Watershed method.

[0058] Briefly, the Watershed is a function that applies a morphological watershed operator to an image (a grayscale image typically). The watershed operator segments images into watershed regions and their boundaries. Considering the gray scale image as a surface, each local minimum can be thought of as the point to which water falling on the surrounding region drains. The boundaries of the watersheds lie on the tops of the ridges. The operator labels each watershed region with a unique index, and sets the boundaries to zero. Typically, morphological gradients, or images containing extracted edges are used for input to the watershed operator. Noise and small unimportant fluctuations in the original image can produce spurious minima in the gradients, which can lead to over segmentation. The use of a smoothing operator, or manually marking seed points, are two exemplary approaches to avoiding over segmentation. Further reference with regard to the Watershed function can be made to, for example, Dougherty, "An Introduction to Morphological Image Processing", SPIE Optical Engineering Press, 1992.

[0059] A set with three members can be used to represent the state of one fingertip: two for the coordinates of the tip and one to represent whether it touches the surface or not (touch state). A stack or queue is a suitable data structure for recording the coordinates when the finger tip touches the surface. A timer or counter may be used to record when the finger tip leaves the surface.

[0060] The task of gesture recognition in accordance with the exemplary embodiments of this invention is to select the correct command/operation from a set of candidates, according to the input gesture. The conditions for starting the gesture recognition step may depend on the content of the set. For example, if only the X mark and check mark (see FIGS. **8**B, **8**C) are included in the set, the condition can be set as a threshold for the number of continuous images which do not contain fingertips. If the zoom in/out gestures are added to the set, a new condition, when two fingertips are detected in one image (see FIG. **8**D), can be used to initiate the gesture recognition process.

[0061] There are many different pattern recognition methods that may be employed for gesture recognition. For example, one based on statistical methods maybe used as it is inherently its robust. Normalization and/or smoothing techniques may be included as part of the gesture recognition process.

[0062] The ability to record the states of fingertip images facilitates gesture recognition. However, these records should be deleted when they are not useful. For example, the records indicating the trace of the fingertip can be deleted as soon as the trace is recognized as a check mark (see FIG.